

***Minnesota Dept. of Commerce,
Division of Energy Resources***

**Distributed Generation
Workshop Interconnection Standards**

Presented by
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October 11, 2011

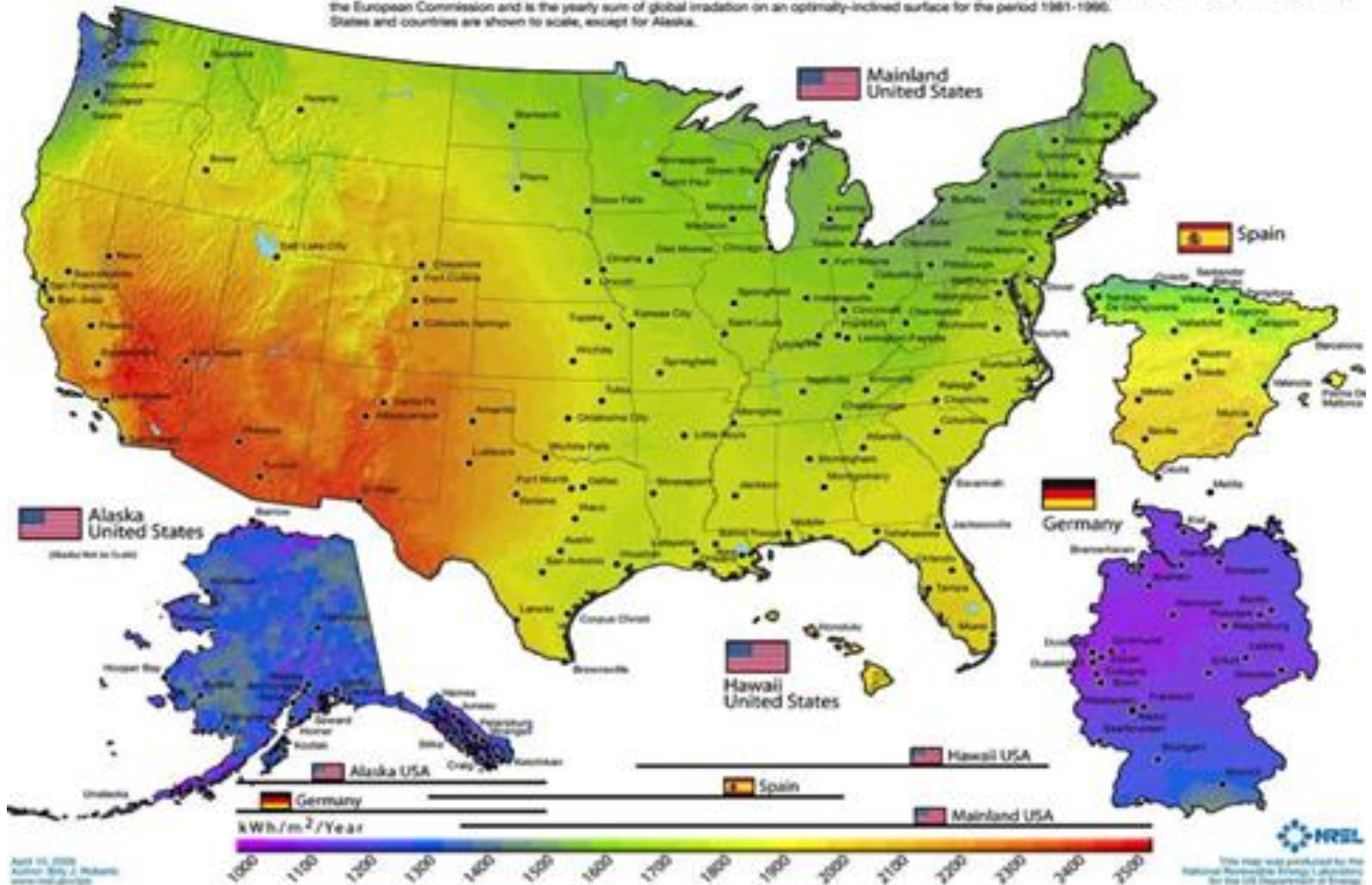
Failte Group

Germans Solar

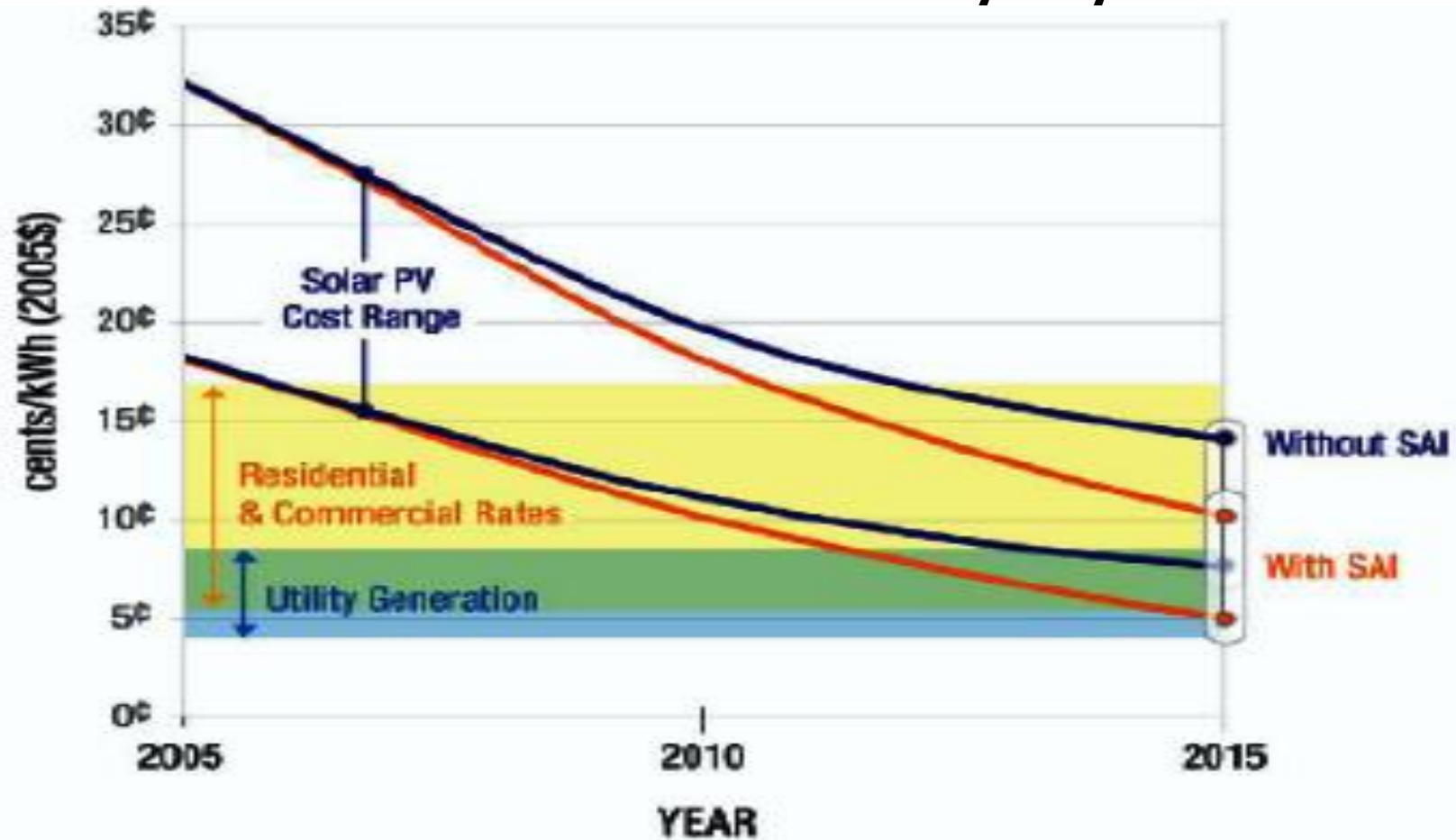


Photovoltaic Solar Resource: United States - Spain - Germany

Annual average solar resource data are for a solar collector oriented toward the south at a tilt = local latitude. The data for Hawaii and the 48 contiguous states are derived from a model developed at SUNY/Albany using geostationary weather satellite data for the period 1998-2005. The data for Alaska are derived from a 40-km satellite and surface cloud-cover database for the period 1985-1991 (PHEL, 2000). The data for Germany and Spain were acquired from the Joint Research Centre of the European Commission and is the yearly sum of global irradiation on an optimally-inclined surface for the period 1981-1990. States and countries are shown to scale, except for Alaska.



Projected Cost Reductions for Solar PV – Grid Parity by 2015



Interconnection Standards

Interconnection standards are the technical and legal procedures for a customer with a DG system to physically connect to the grid.

PV System Codes and Standards

Source	Documents
IEEE SCC21 – Standards Coordinating Committee on Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage	<ul style="list-style-type: none">• IEEE 1547 series (DER up to 10 MVA)• Stand alone PV systems, batteries (several)• P2030 (Smart Grid – New initiative)
Underwriters Laboratories Inc. (UL) PV Standards Technical Panels	<ul style="list-style-type: none">• UL 1703 (PV modules)• US 1741 (Inverters, charge controllers)
NFPA	NEC, Article 690 (solar Photovoltaic Systems)
ASTM E44.09 – Technical Committee on Photovoltaic Electric Power Conversion	Several addressing PV module and array testing
IEC TC82 – Solar photovoltaic energy systems	Several addressing measurement, safety, test procedures

What It Looks Like



Puget Sound Solar – Seattle, WA



Southwest Windpower's
Skystream (2.4 kW peak)



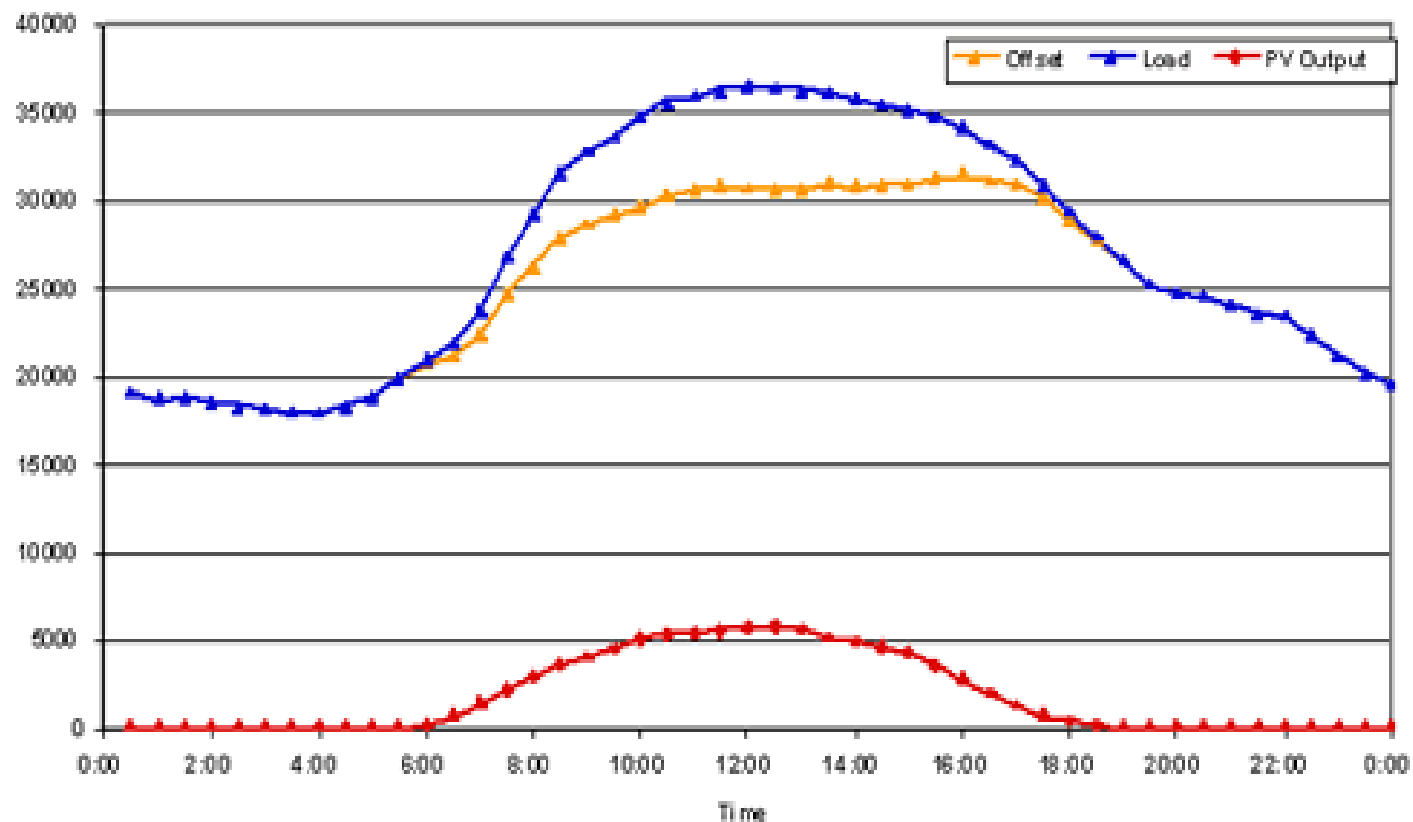
Minneapolis Convention Center
600 kW

Why Solar DG?

- PV solar systems generate the most electricity during the middle of the day, when demand and the cost of electricity are highest. With net metering, individual PV systems can offset expensive peak electricity purchases, resulting in lower electricity bills for all consumers.
- Each megawatt (MW) of PV solar power will prevent 25,000 tons of air pollution over its useful life and reduce harmful particulate emissions from fossil-fuel generation.
- Solar is an emerging jobs engine. PV solar creates more jobs per MW than any other energy source. Each MW manufactured and installed in the US will directly employ 24 people.²
- As DG solar reaches higher market penetrations, it can make the electricity grid more reliable and secure. It can smooth out the electricity demand curve and reduce the need for expensive new base-load power plants to meet peak loads.

PV impact on Load

Average summer profile for 10x Olympic PV and Homebush Bay load

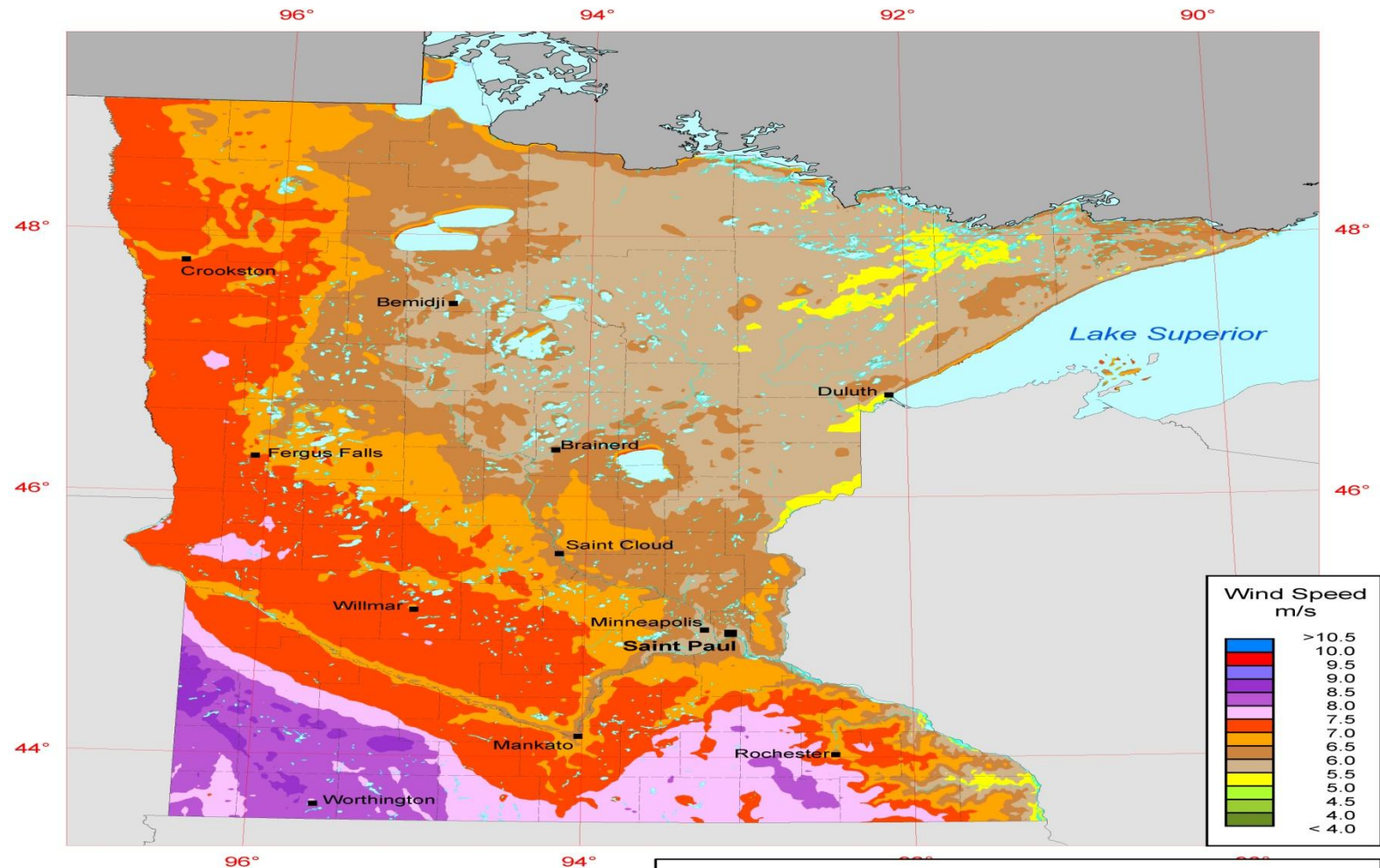


**When there's a huge solar energy spill,
it's just called a "nice day"**

www.votesolar.org



Minnesota - Annual Average Wind Speed at 80 m



50 0 50 100 150 Kilometers
25 0 25 50 75 100 Miles

Source: Wind resource estimates developed by AWS Truepower, LLC for windNavigator®. Web: <http://www.windnavigator.com> | <http://www.awstruepower.com>. Spatial resolution of wind resource data: 2.5 km. Projection: UTM Zone 15 WGS84.



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NREL
NATIONAL RENEWABLE ENERGY LABORATORY

11-OCT-2010 1.1.1

MINNESOTA



NET METERING

C 2007	C 2008	C 2009	B 2010
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Eligible Renewable/ Other Technologies:	Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Municipal Solid Waste, CHP/Cogeneration, Anaerobic Digestion, Small Hydroelectric, Other Distributed Generation Technologies
Applicable Sectors:	Commercial, Industrial, Residential
Applicable Utilities:	All utilities
System Capacity Limit:	Less than 40 kW
Aggregate Capacity Limit:	No limit specified
Net Excess Generation:	Reconciled monthly; customer may elect to take compensation as a payment or as a bill credit at the retail utility energy rate
REC Ownership:	Not addressed
Meter Aggregation:	Not addressed

Recommendations:

- Remove system size limitations to allow customers to fully meet average on-site energy needs
- Adopt safe harbor language to protect customer-sited generators from extra and/or unanticipated fees

INTERCONNECTION

F 2007	F 2008	F 2009	D 2010
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Eligible Renewable/ Other Technologies:	Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Geothermal Electric, Fuel Cells, Municipal Solid Waste, CHP/Cogeneration, Microturbines, Other Distributed Generation Technologies
Applicable Sectors:	Commercial, Industrial, Residential, Nonprofit, Schools, Local Government, State Government, Fed. Government
Applicable Utilities:	All utilities
System Capacity Limit:	10 MW
Standard Agreement:	Yes
Insurance Requirements:	Vary by system size and/or type; levels established by commission
External Disconnect Switch:	Required
Net Metering Required:	No

Recommendations:

- Remove requirements for redundant external disconnect switch
- Prohibit requirements for additional insurance
- Further delineate tiers to accommodate different levels of complexity among system types and sizes

Minnesota's net metering legislation was adopted in the early 1980s. Net metering is offered for systems up to 40 kW with no limit on aggregate program capacity. The standards are unlike most other net metering policies in that they require utilities to issue a check at the end of the month in order to purchase annual NEG at the retail rate. The Minnesota Public Utilities Commission developed generic interconnection guidelines in 2004 pursuant to Minnesota law. These standards are limited to the interconnection of systems 10 MW or less and require utilities to provide streamlined uniform interconnection applications and a process that addresses safety, economics and reliability issues. The standards also require an external disconnect switch and additional insurance.

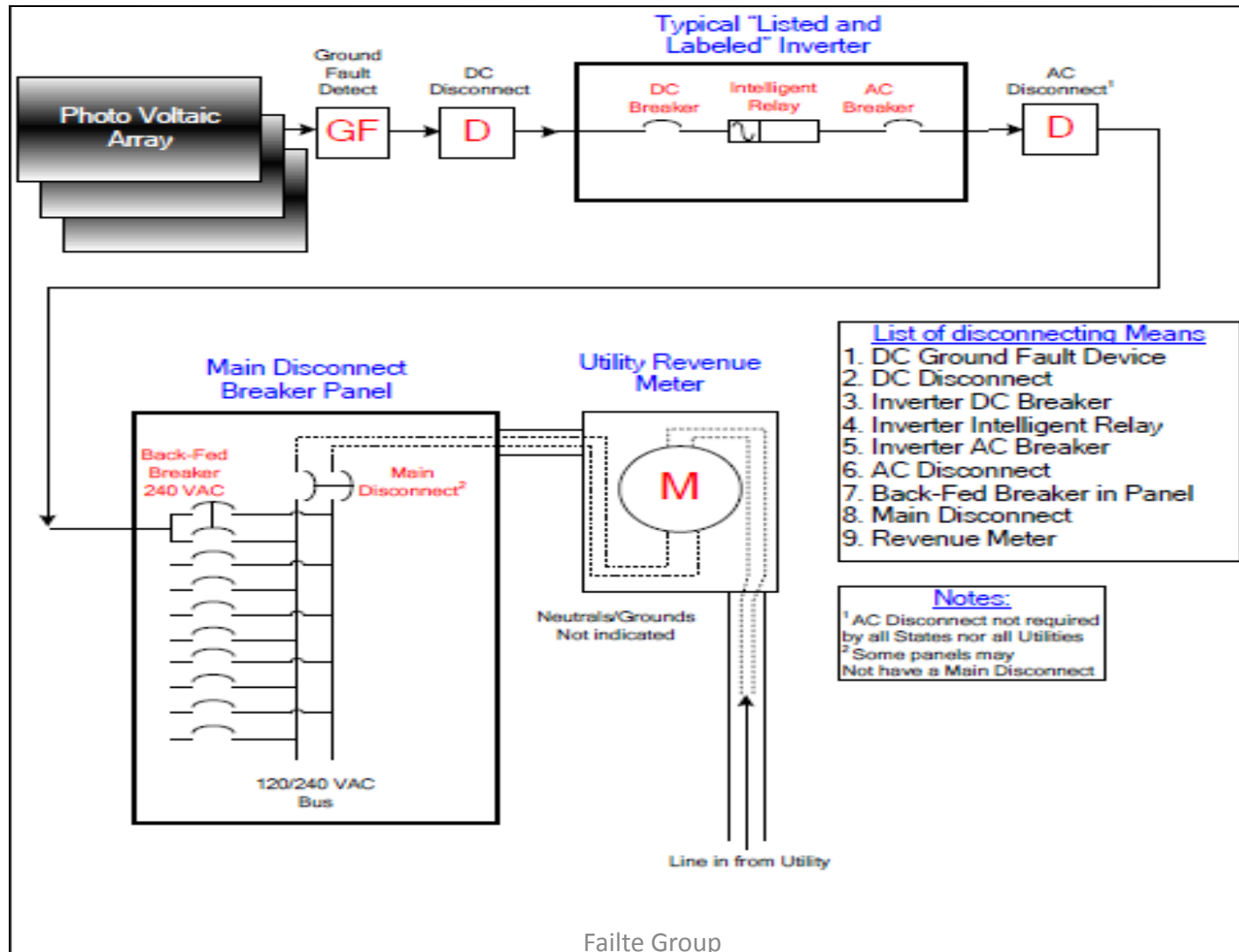
NEC Article 690: Solar Photovoltaic Systems

- I. General (definitions, installation)
- II. Circuit Requirements (sizing, protection)
- III. Disconnect Means (switches, breakers)
- IV. Wiring methods (connectors)
- V. Grounding (array, equipment)
- VI. Markings (ratings, polarity, identification)
- VII. Connection to Other Sources
- VIII. Storage batteries
- IX. Systems over 600 volts

Zero Energy Homes



PV Components



Module Information

- Manufacturer's "cut sheet" for the specific model
- Listing – The module should be listed to UL 1703. For a current list of modules that are listed to UL 1703 visit the California website www.gosolarcalifornia.com
- Listing label information

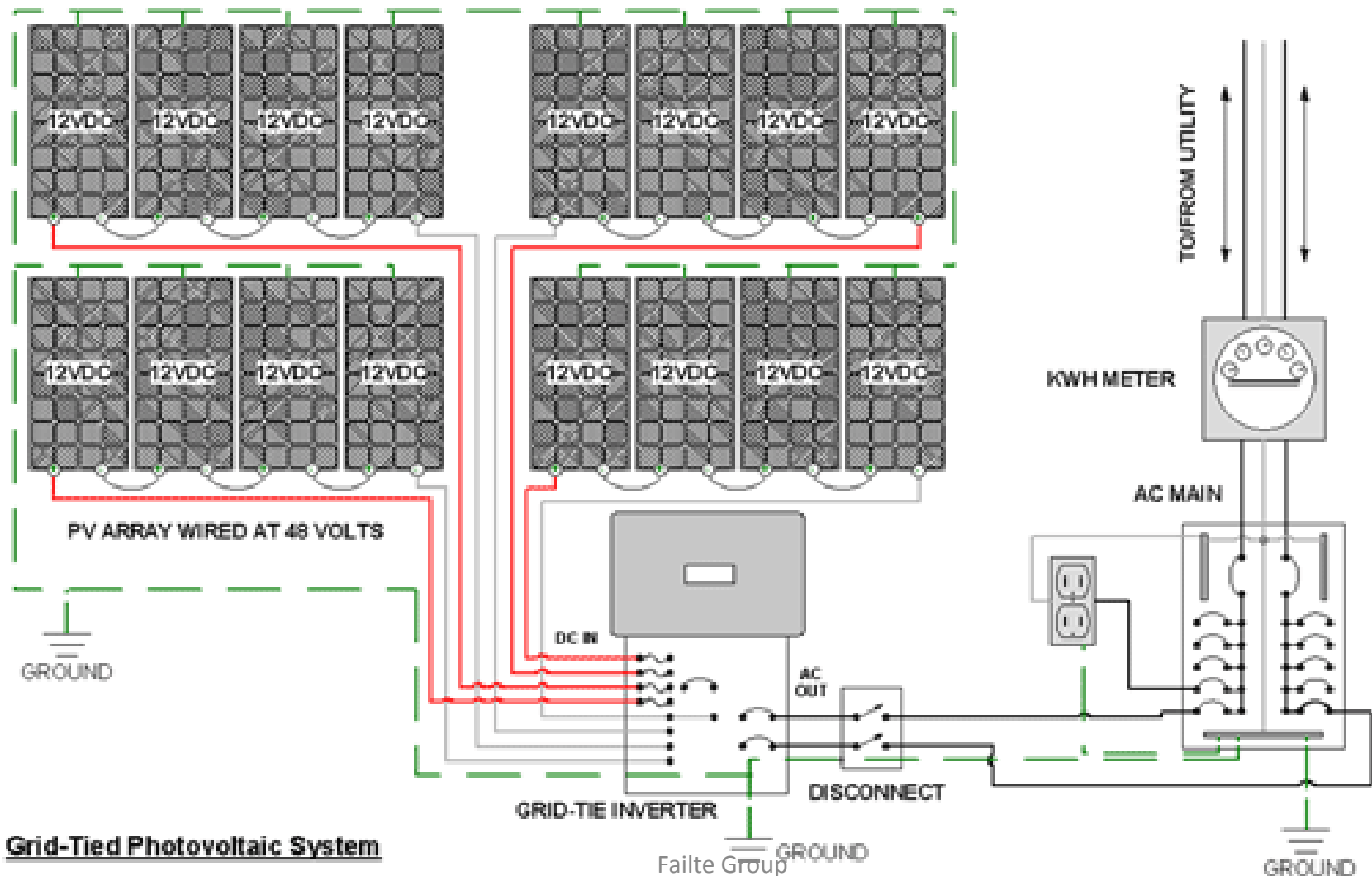
Home PV System



One-line Diagram

- Should have sufficient detail to call out the electrical components, the wire types and sizes, number of conductors, and conduit type and size where needed.
- Should include information about PV modules and inverter(s).
- Should include information about utility disconnecting means (required by many utilities).

PV Grid Tied



Commercial PV System



Failures Conditions Needed for Inverter to “Back feed” on a De-energized System

1. Inverter fails to disconnect automatically and continues exporting power without the necessary external voltage source present
2. Anti-islanding, voltage and frequency protection fail
3. Output of the inverter \sim matches the connected load such that over current protection (fuse) does not operate

Even if the above were to occur, the requirement to test and ground the line before working on it should protect the line worker

UL Testing

- Normal Safety Related Tests
- Abnormal Safety Related Tests
- Performance Related Tests

Electrical Equipment Listing

- Authority Having Jurisdiction (AHJ's) generally require listing for components and electrical hardware
- Some components available for PV systems may not have applicable or any listing.
- Recognized testing laboratories include:
 - UL
 - CSA
 - ETL Semko (Intertek)
 - TUV

IEEE 1547 Voltage and Frequency Tolerances

Voltage Range (% Nominal)	Max. Clearing Time (sec)*
$V < 50\%$	0.16
$50\% \leq V < 88\%$	2.0
$110\% < V < 120\%$	1.0
$V \geq 120\%$	0.16

(*) Maximum clearing times for $DG \leq 30$ kW;
Default clearing times for $DG > 30$ kW

Frequency Range (Hz)	Max. Clearing Time (sec)*
$f > 60.5$	0.16
$f < 57.0^*$	0.16
$59.8 < f < 57.0^{**}$	Adjustable (0.16 and 300)

(*) 59.3 Hz if $DG < 30$ kW

(**) for $DG > 30$ kW

Additional Requirements

- Cease to energize for faults on the utility system
- Cease to energize prior to circuit reclosure
- Detect island condition and cease to energize within 2 seconds of the formation of an island (“anti-islanding”)

California List of PV Equipment

PV system components (modules, inverters, and system performance meters) must be certified through the California Energy Commission's PV system certification program. The CEC provides a list of currently certified eligible equipment on the Go Solar California site at <http://www.gosolarcalifornia.ca.gov/equipment/index.html> or through its Call Center: (800) 555-7794.

Inverter Information

- Mode; number and manufacturer's "cut sheet" for the specific model
- Listing-is the inverter listed to UL 1741 and labeled "Utility-interactive"? For current list of compliant inverters, visit California Solar Program website www.gosolarcalifornia.com
- Maximum continuous output power at 40° C

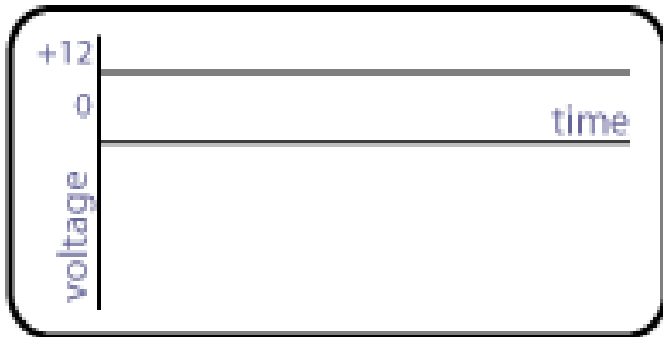
Commercial PV System



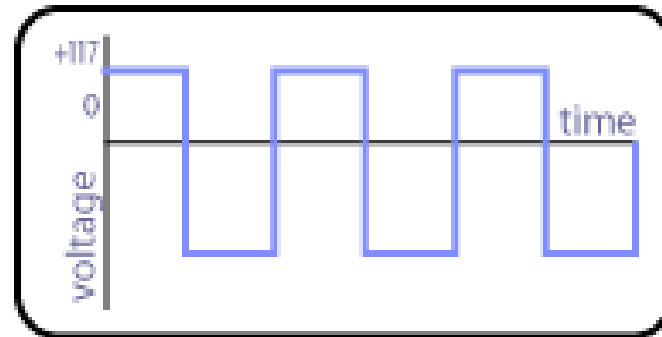
PV Impact on Grid

- Possible Islanding Operation.
- Single Phase Open.
- AC Over voltage condition.
- AC Under voltage condition.
- Over frequency condition.
- Under frequency condition.
- AC Over current condition.
- Short circuit condition.

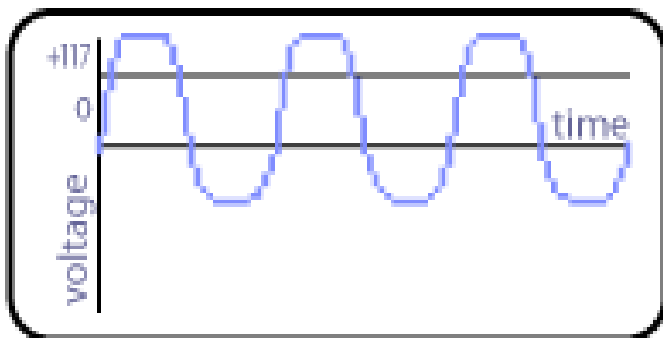
DC to AC Conversion



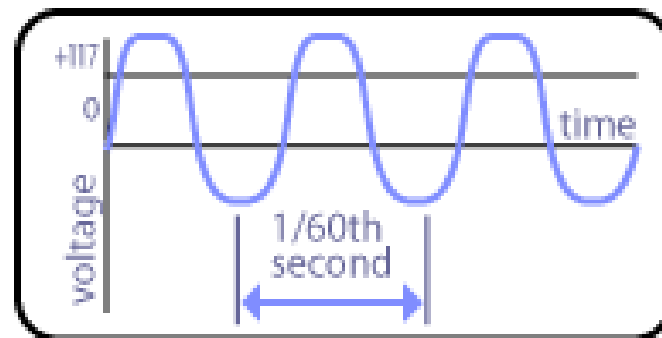
DC 12 volt power



AC square wave power



AC modified sine wave power

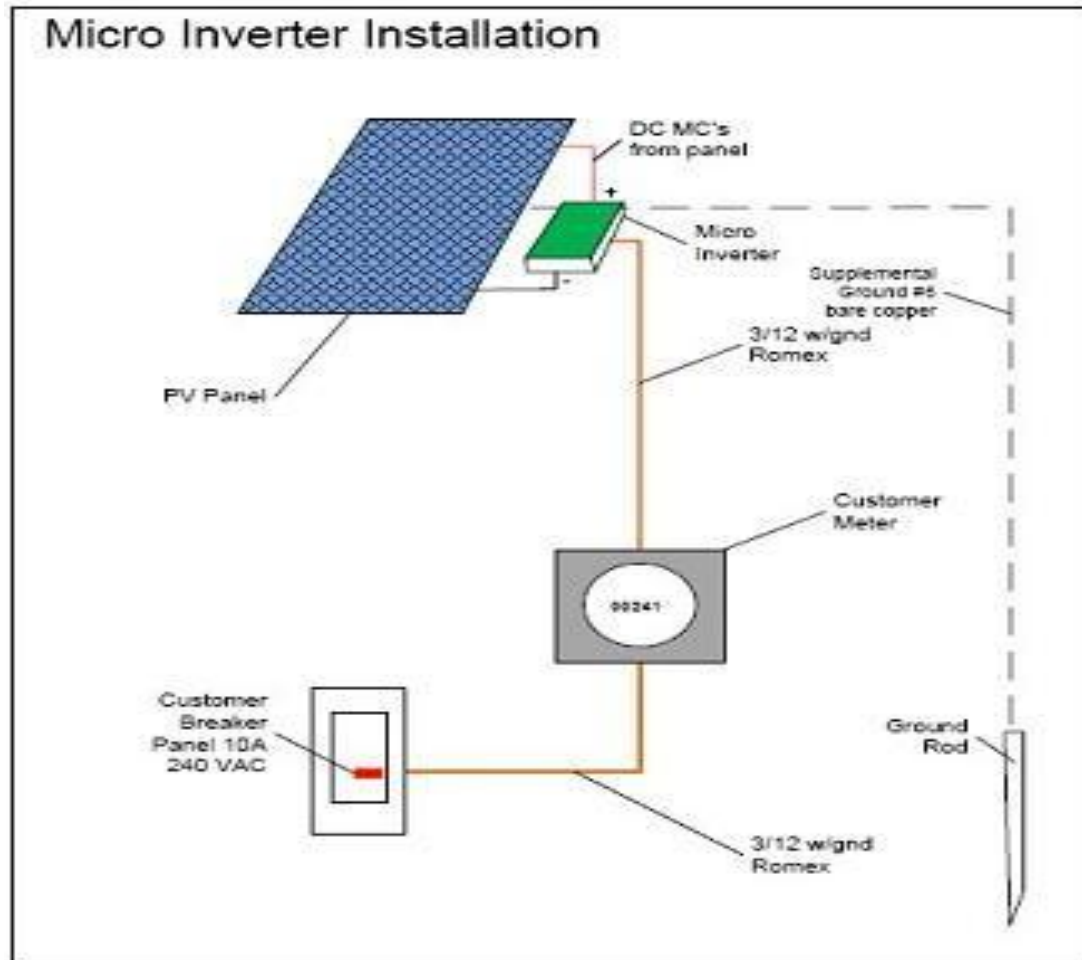


AC sine wave power

Solar Bear



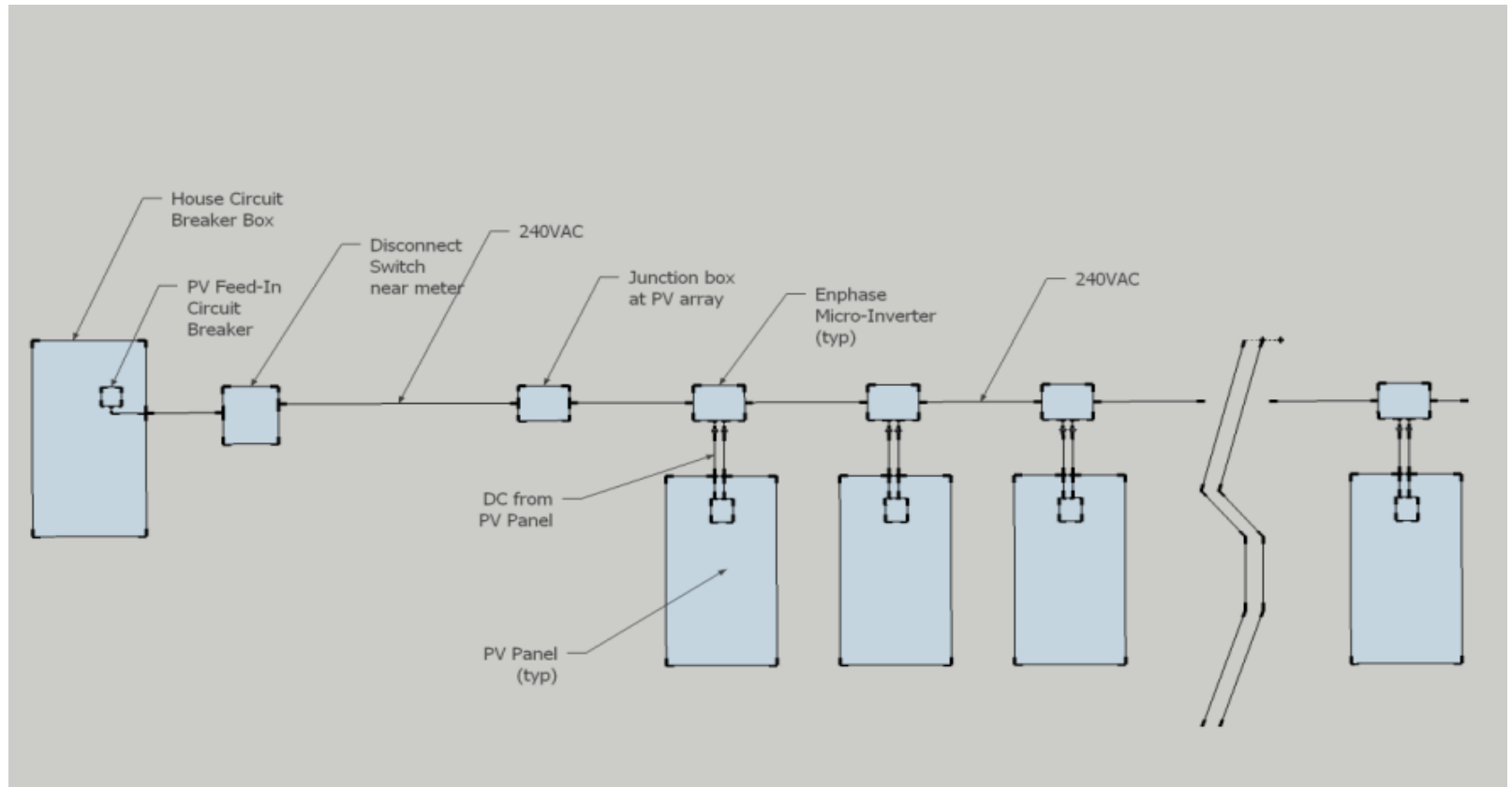
Micro Inverter



Micro Inverter



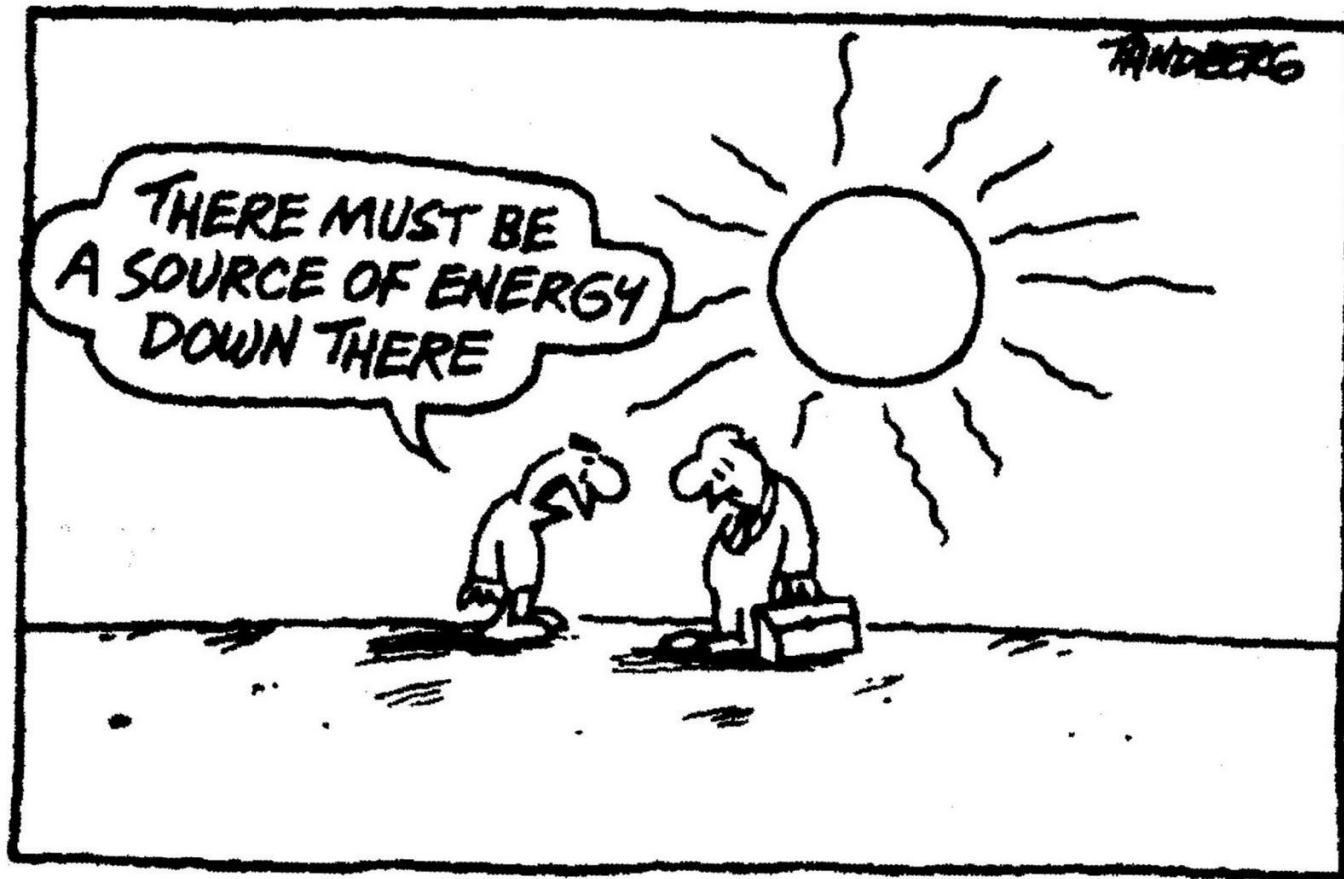
Micro Inverter One Line Diagram



Micro Inverter Installation



PV Energy Source

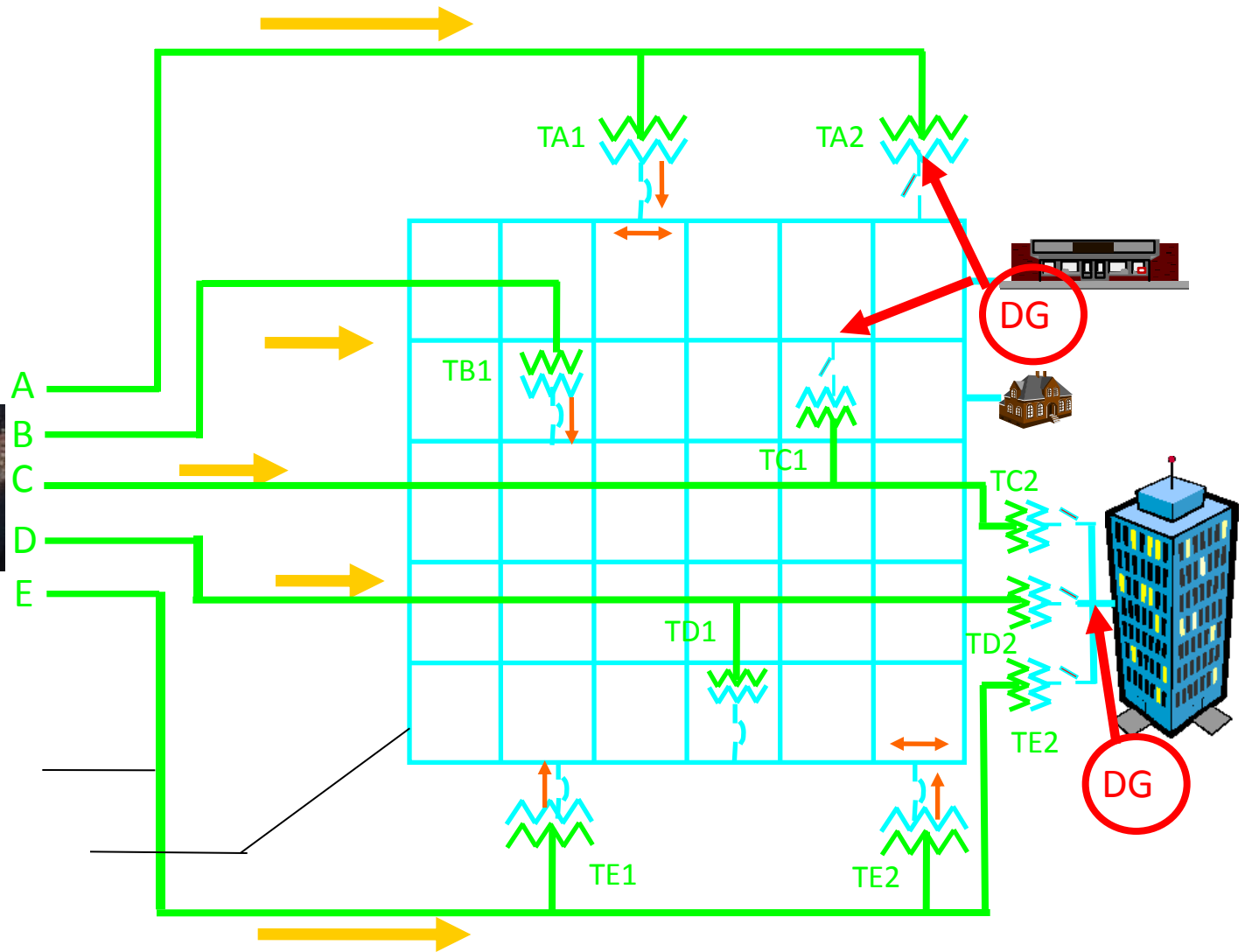


The “Back feed “ question:

Three typical electrical design configurations found in most Distribution systems were identified and the Canadian utilities were asked to describe how they manage the risk for Back feed in each Scenario, **to protect the safety of workers.**

Scenario 1: Three phase common core transformer installation (with an open phase) Scenario 2: Three phase transformer installation with an open phase –LV Phase-Phase LV Load Scenario

3: Three phase transformer installation with an open phase –Downed Conductor

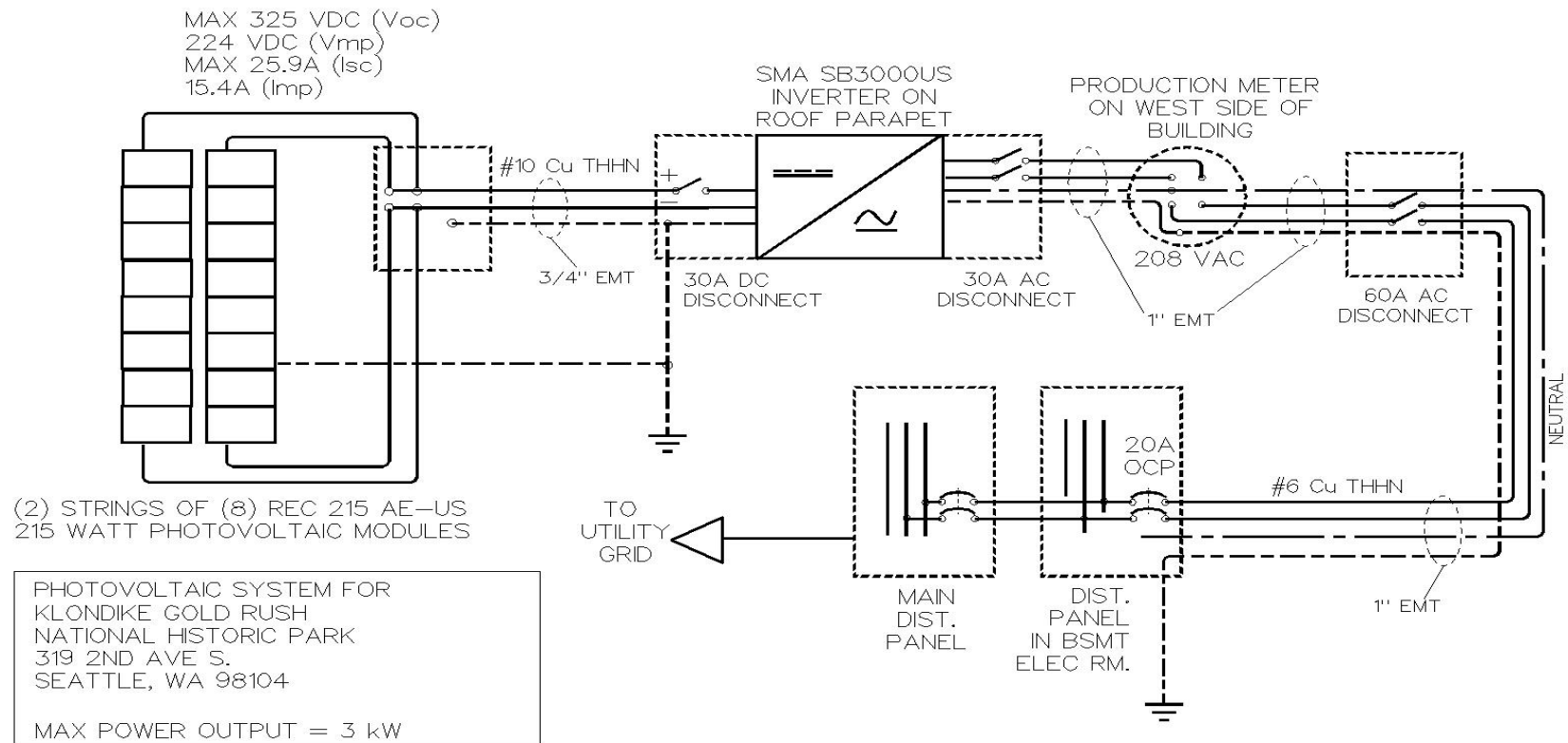


Failte Group

Transformer & Network Protector



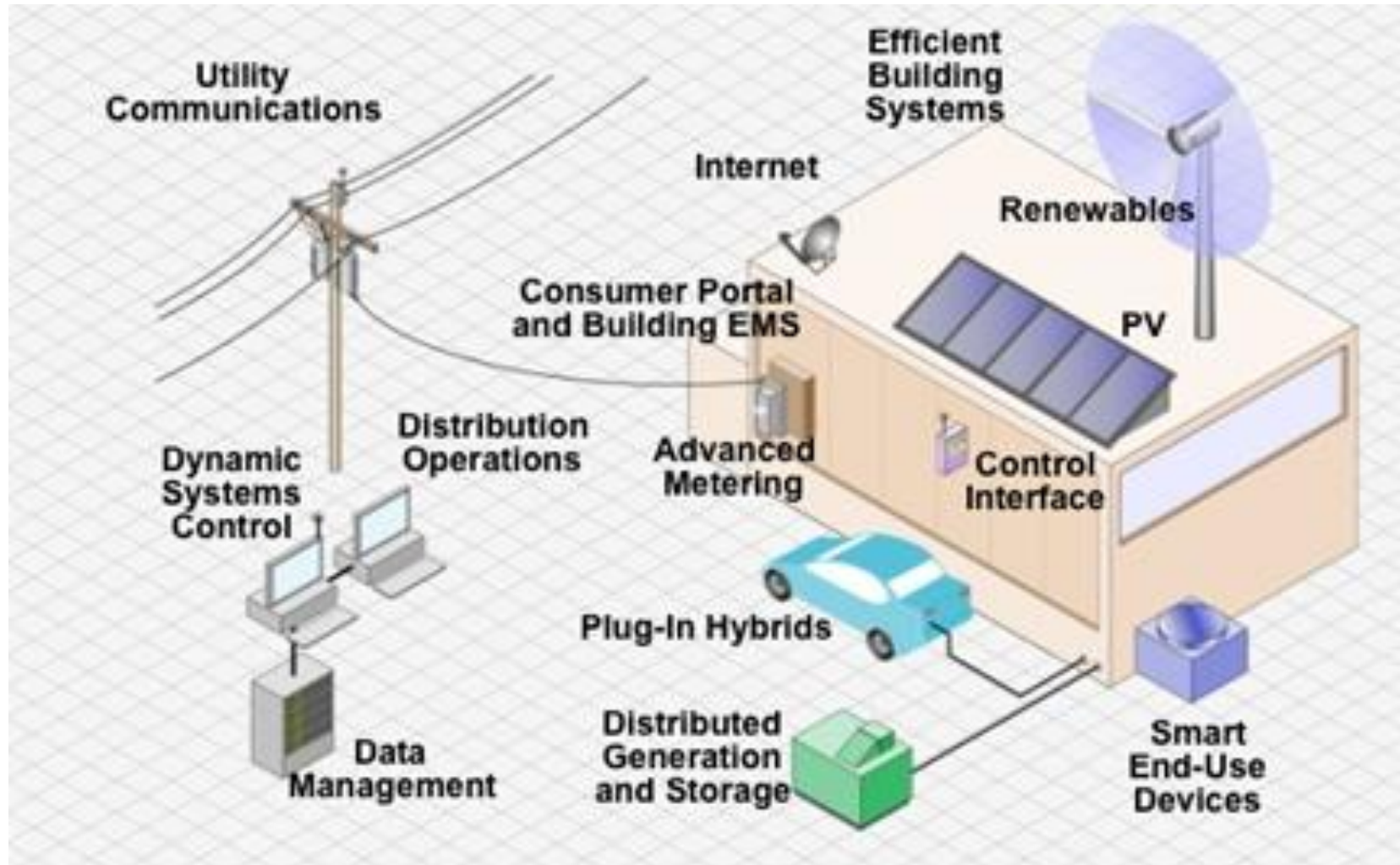
Klondike One Line Diagram



Florida Power & Light



Elements of Smart Grid



New Business PV

